2019 WERC Design Contest
TASK 2
Industrial Stack Exhaust Emissions Testing Using Drone Technology

Background

Typical air environmental permits for industrial sources include requirements for testing the various emission points/stacks (e.g., scrubbers, thermal oxidizers, etc.) across the facility to prove compliance with emissions limits that are applicable to the facility. Currently, EPA-approved stack testing methods (e.g., FTIR, FID, etc.) require substantial time and resources to collect and analyze data. However, these EPA-approved methods are legacy methods and have not been updated to account for the technological advances in today's society. The technological advancement of interest in this case is drone technology. This project looks at utilizing drone technology as a means of performing on-demand stack exhaust emissions testing that is both cost effective and has ease-of-implementation.

The drone selected for emission monitoring is a helicopter platform produced by Yuneec called the Typhoon H. This drone was chosen for its exceptional flight stability, hovering capabilities, and long flight duration of 25 minutes. The Yuneec Typhoon H has an overall size of 20.4”X18”X12” (520X457X310mm) and a takeoff weight of 68.8oz (1950g). The user manual for the Yuneec Typhoon H can be found at the following website: https://static.bhphotovideo.com/lit_files/319649.pdf

It is important to note that the flight duration and max payload of the drone will be severely affected by altitude and weather. The specifications listed in the manual describe drone performance at sea level and under ideal weather conditions.

The FFA regulates drones to a maximum flight height of 400ft and a maximum weight of 55lbs. Drone flights are highly regulated and it is important to understand them before attempting any teat flights. For a full list of FFA regulations regarding unmanned aerial vehicles refer to the following link: https://www.ecfr.gov/cgi-bin/text-idx?SID=1251031ae9cc2c0e6e2b194ba955cc4c&mc=true&node=pt14.2.107&rgn=div5

Problem Statement

Your team will design a monitoring mechanism to be affixed to a Yuneec Typhoon H drone for stack exhaust emissions testing. Specific pollutants of interest include volatile organic carbons (VOCs) and particulate matter (PM). The monitoring mechanism must have a form factor compact enough to be affixed to the drone and must be capable of monitoring an individual stack exhaust for the pollutants of interest. The monitoring mechanism must generate reliable datasets by which an emission rate can be determined in either pounds per hour (lb/hr) or tons per year (tpy). The mechanism must be able to operate in adverse weather conditions such as wind, rain, and snow.

Design Considerations

Your proposed design should provide specific details and outcomes as follows:

- State the proposed monitoring method(s) to be used for measuring both VOCs and PM.

- The design should incorporate a monitoring method capable of being affixed to a Yuneec Typhoon H drone.
- The design should be scalable (i.e., capable of being deployed across a variety of different industrial settings).
- Sensor data collection must take place on a minute by minute basis
- Recorded data must be downloaded to a computer in an easily readable format after the flight
- Address how data will be collected, stored, and transferred to a user interface.
- The application and cost of the following design conditions should be addressed in your report but do not have to be included in your bench scale prototype
    - Address materials of construction needed to handle a range of ambient conditions (e.g., hot thermal oxidizer exhaust, acidic scrubber exhaust, etc.).
    - Address design considerations for variable weather conditions (e.g., wind, rain, snow, etc.).

Bench Scale Demonstration

1. **Ground level testing:** Your team will demonstrate your design at bench scale level using known calibration gases containing known concentrations of VOCs and/or PM. With your prototype detached from the drone and placed near a test cylinder containing the calibration gases, the gases with known concentrations of VOCs and PM will be released from the cylinder. Your team design will be evaluated on the accuracy of the measurements taken by your prototype.
2. **Flight testing:** Your bench scale working prototype should be able to attach to a Yuneec Typhoon H drone. A drone will be provided by Intel for the competition and the flight will be conducted by a licensed drone pilot from NMSU. The drone camera will be detached to allow for your team devices to be attached. The drone with your apparatus attached will then fly along a prescribed flight path. The drone will perform a 50ft radius circle around the NMSU Co-generation Plant exhaust stack at an altitude of 150ft. Your prototype must measure the pollutant concentrations and provide data on these measurements on per minute basis. Your team will be evaluated on the time it takes to attach and detach your prototype from the drone, the frequency of data sampling, and the readability and accessibility of the collected data.

Written Report Requirements

The written report should demonstrate your team's insight into the full scope of the issue and include all aspects of the problem and proposed solution. The report will be evaluated for quality of writing, organization, clarity, reason, and coherence. Standards for publications in technical journals apply. In addition to the listed requirements, your report must address in detail the items highlighted in the Problem Statement, Design Considerations, and Evaluation Criteria.

Evaluation Criteria

Each team is advised to read the Participation Guide for a comprehensive understanding of the contest evaluation criteria. Please visit the WERC website: https://iee.nmsu.edu/outreach/events/international-environmental-design-contest/guidelines/ for a copy of the Public Involvement Plan and Participation Guide and other important resources. Your proposed solution will be evaluated on the following:

Technical report/ presentation:

- Technical fundamentals, performance, safety, and other issues stated in the Problem Statement.
- Potential for real-life implementation.
- Thoroughness and quality of the economic analysis.
- Originality, innovativeness, functionality, ease of use, maintainability, reliability, and affordability of the proposed technology.
- How well the bench-scale represents your full-scale design concept.

Ground level testing:

- The quality of your measured data - the bench-scale data collected will be compared to the known concentrations of VOCs and/or PM.

Flight Testing:

- The amount of time needed to attach/ detach the prototype to/from the drone
- The ability of your design to take data on a per minute basis
- The ability for this data to be collected on a computer for analysis post flight

Other specific evaluation criteria may be provided at a later date.